REMARKS

This amendment is responsive to the Office Action mailed on March 1, 2011.

I. New Dependent Claims 24, 25, 26, and 27

New dependent claims 24, 25, 26 and 27 have been added, which depend on independent claims 8, 17, 22, and 23 respectively. Each of the new dependent claims limits the method recited in the independent claim it depends on to a method in which no material is removed from the treated substrate, i.e. the surface of the refractory material, during the exposure to the laser beam or treatment with the laser radiation. These dependent claims are supported by the disclosure on page 3, lines 15 to 19, of the originally filed specification.

This differs from the method described in the technical article of Wang, et al. Wang, et al, teaches that some of the components of the refractory material, in particular silicon dioxide, are volatilized to some extent during their laser treatment. This is understandable because the laser used by Wang has 10 times the power density of

the applicants' laser and correspondingly greater power densities were applied to the surface during the laser treatments according to Wang, et al, which will be explained more fully herein below in connection with the rejections based on the prior art disclosures.

II. First Obviousness Rejection

Claims 22 and 23 were rejected as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301.

A. Applicants' Claimed Methods of Claims 22 and 23

Applicants' claimed method of processing a glass melt according to claims 22 and 23 comprises bringing the glass melt in contact with the surface of a refractory material of the stated composition after the surface has been treated with laser radiation to form a closed vitreous layer containing components of the refractory material.

However claims 22 and 23 have been amended to provide an important connection: the method of processing the glass melt is limited to methods in which the glass melt contacts the closed

vitreous layer. The closed vitreous layer provides the advantageous resistance to corrosion of the refractory material due to contact with the hot glass melt, which provides a better glass product of improved quality and also enhances the surface life of the refractory material. Thus during the processing the closed vitreous layer must protect at least a portion of the surface of the refractory material from direct contact with the glass melt.

Furthermore new dependent claims 26 and 27 have been added, which claim embodiments of the method that are limited to laser treatments of the refractory material surface with operating parameters, such as laser power, that do not cause any removal of material from the surface of the refractory material, for example by volatilization or spalling. These new dependent claims are supported by the disclosures in the paragraph on page 3, lines 15 to 19, of applicants' originally filed specification.

B. The Content of the Cited Prior Art

The content of the Recasens prior art U.S. Patent has been described in the previous Office Action and on pages 12 and 13 of the applicants' amendment of October 13, 2010.

Recasens describes special compositions of refractory bricks used in furnaces for production of glass, in which the refractory bricks come into contact with a hot glass melt. Recasens discloses that the hot glass melt can cause cracking and corrosion due to contact with the surface of the refractory bricks. Recasens discloses certain refractory brick chemical compositions that are especially resistant to such corrosion.

However Recasens does **not** disclose or suggest any laser treatments of the surface of the refractory bricks that are performed in order to improve the resistance of the refractory material surface to corrosion due to contact with the glass melt.

Of the two cited references, only the technical article of Wang, et al, discloses a laser treatment of refractory material by a CO_2 laser beam.

The technical article by Wang, et al, does disclose laser treatment of a refractory material surface with a higher power CO_2 laser beam that causes melting of a surface layer of the refractory material and evaporation of surface material (The CO_2 laser beam of Wang, et al, is a 1000 W laser with a beam diameter of 4 mm compared to the applicants' CO_2 laser beam with a power of 100 W

and a diameter of 4 mm -- see 2. Experimental Procedure on page 295 of Wang, et al, and page 5, lines 9 to 16, of applicants' specification). However Wang, et al, teach that material is removed from the surface of the refractory material because of the high power densities used in their laser treatments due to evaporation (see the last six lines of the abstract). While reducing the scan rate of the laser beam over the surface does reduce the losses due to evaporation, the reference shows that there is still substantial evaporation of material, especially silica, due to the high power densities (see section 3.3 on page 297 and figs. 7a and 7b). Wang, et al, also teach that significant composition changes occur in the refractory surface due to the exposure to the high power densities (see the discussion in section 4.1 on page 298).

This contrasts to applicants' disclosure that their laser treatment is sufficient to produce a closed vitreous layer, but is not so powerful that it removes material from the surface (see page 3, lines 15 to 19, of applicants' originally filed specification). New dependent claims 26 and 27 are limited to embodiments in which no material is removed from the surface by the laser treatment and thus claim embodiments that are <u>not</u> disclosed or suggested by Wang, et al.

Furthermore Wang, et al, teach that the surface layer formed by their high power laser is basically polycrystalline in nature and thus cannot be vitreous in any embodiments as alleged in the paragraph extending from pages 4 to 5 of the Office Action. The results section 3.2 on page 296 of Wang, et al, (see figs. 3 and 4 of Wang, et al) teaches as follows:

> **"The microstructure of the laser-molten zones was characterized by a dendrite structure and the microstructure in the top region displayed a non-oriented dendrite while the microstructure in the middle and bottom regions showed an oriented dendrite nearly perpendicular to the molten surface."**

One skilled in the art knows that a dendrite structure is a branched structure formed by growth of crystal phases in polycrystalline material (not a single crystal). This can be confirmed by consulting an on-line Encyclopedia such as Wikipedia or the dictionary.

In addition, X-ray diffraction results disclosed on page 297 teach that the dominant phase in the surface layer after laser treatment is changed from mullite to corundum and a small amount of c-ZrO_2. Mullite and corundum are both crystal materials and hence Wang, et al, explicitly teaches that the dominant phase in their surface layer is crystalline (see sub-section 3.3 in Wang, et al, first paragraph, page 297).

C. Validity of Wang, et al, as a Prior Art Reference Appears to be Questionable

The validity of Wang, et al, as a prior art reference is questionable because the publication dates on the PTO-892 and on the copy of this technical article provided by the Office are incomplete since they only indicate the year of publication. However the month and date of publication here are critical.

In order to be a prior art reference under 35 U.S.C. § 102 (b), i.e. a statutory bar, the technical article must have publication date and must have been distributed to the public at least one year prior to the U.S. filing date of the above-identified U.S. Patent Application. However the U.S. filing date is the date of the filing of the PCT International application in Europe, namely March 26, 2005, not the date of receipt of the application papers in the U.S. Patent Office, in accordance with M.P.E.P. § 1896 and § 1893.03 (b). Without the month and day of publication of Wang, et al, one cannot determine whether the aforesaid filing date in Europe is more than one year later than that of Wang, et al.

Furthermore the International Application has a priority date of March 30, 2004, the filing date of 10 2004 015 357.4 (the priority

document) in Germany. Thus it is only necessary for the applicants to file a certified English translation of 10 2004 015 357.4 to overcome Wang, et al, if it has a publication date in 2004 that is later than March 30 (provided it is not a reference under 35 U.S.C. § 102 (b) but is a valid reference under other sections of the statute), although applicants may also need to file an affidavit under Rule 131 to antedate Wang, et al. Since the March 30 date in 2004 is within three months of the beginning of 2004, it is highly likely that applicants can produce drafts of the German Patent Application and memos to support a date of invention in 2003.

Thus knowledge of the complete publication date in the case of Wang, et al, is an essential prerequisite for a valid rejection based on the combination of Wang, et al, with Recasens, et al. Furthermore even that would not be enough to establish that Wang, et al, is a valid reference, because a technical article is not a valid reference until the magazine or technical article is actual distributed to the public according to M.P.E.P. § 706.02 (a) and *Protein Foundation Inc. v. Brenner*, 260 F. Supp. 519, (D.D.C. 1966). From the facts of this Court decision it seems clear that the publication date of the Wang reference must be at least <u>several weeks</u> prior to the applicants' priority date to be a valid prior art reference (if it is not a statutory bar).

In any case without the complete publication date for Wang, et al, it is respectfully submitted that the Office has not met the burden of showing that it is a valid prior art reference under any portion of the statute that can be combined with other prior art references to reject the claimed invention is obvious. If the completely publication date cannot be determined, perhaps the rejection should be withdrawn or Wang, et al, replaced with another earlier prior art reference.

D. Reasons for Obviousness Presented in the Office Action

This sub-section considers the reasons for obviousness of claims 22 and 23 presented in the Office Action, assuming that Wang, et al, is a valid prior art reference that can be employed under 35 U.S.C. 103 (a) (which in applicants' opinion has not been proven adequately by the facts regarding the effective date of this reference disclosed in the Office Action).

Page 4 of the Office Action correctly notes that Recasens, et al, teach that their refractory material includes a vitreous or glassy phase. However Recasens does <u>not</u> subject their refractory material to a high power laser beam that heats the surface of the refractory

material to such an extent that not only is a melt layer formed on the surface but also material is evaporated from the surface in the case of all the treatments as in the laser treatment of Wang, et al. Such high temperature treatments of vitreous material may provide an opportunity for the vitreous material to ceramicize, i.e. to crystallize, but also might promote cracking due to evaporation.

The Office Action alleges that one cannot determine the nature of the surface layer produced by the laser treatment of Wang, et al, i.e. one cannot determine whether it is vitreous or crystalline in the paragraph extending from page 4 to page 5 of the Office Action.

On the contrary, the Wang reference is not silent regarding the nature of the laser treated surface layer in Wang, et al, -- it teaches the <u>opposite</u> from the claimed invention, because it teaches that it is crystalline or polycrystalline in nature, not vitreous. Vitreous is the opposite from crystalline and means that the layer is glassy. As noted above subsection 3.2 of Wang, et al, teaches that the surface layer formed has a dendrite structure, which is a branched polycrystalline structure. Furthermore its primary crystalline phase is corundum according to subsection 3.3 of Wang, et al.

A prior art reference that <u>teaches the opposite</u> from the

claimed invention should not be combined with other prior art references to reject the claimed invention under 35 U.S.C. § 103 (a). See M.P.E.P. § 2145 X and also the Federal Circuit Court of Appeals has said:

> **"That the inventor achieved the claimed invention by doing what those skilled in the art suggested should not be done is a fact strongly probative of nonobviousness."** in *Kloster Speedsteel AB v. Crucible Inc.,* 230 U.S.P.Q. 81 (Fed. Cir. 1986), on rehearing, 231 U.S.P.Q. 160 (Fed. Cir. 1986)

A layer that is polycrystalline is not vitreous -- they are the opposite from each other.

Furthermore Wang, et al, teaches the opposite from the applicants' invention regarding evaporation of material during the laser treatment. The conclusions on page 301 of Wang, et al, (conclusion 3) state as follows (for all embodiments disclosed by Wang):

> **"Laser melting treatment caused the selected evaporation of the refractory. An evaporation mechanism, that laser irradiation induced the decomposition of $Al_6Si_2O_{13}$ into Al_2O_3 and SiO_2 and the subsequent entire evaporation of SiO_2 and the partial evaporation of Al_2O_3. The slower the scanning velocity was, the larger the evaporation amount of Al_2O_3 should be."**

This paragraph of Wang, et al, teaches that the evaporation of material always occurs and that **all** of the SiO_2 in the refractory material of the surface treated layer is evaporated. That is why the

predominant phase in the surface layer formed by the laser treatment of Wang, et al, is corundum, i.e. Al_2O_3.

In contrast, applicants' originally filed specification on page 3, lines 15 to 19, teaches that no refractory material is removed from the surface by the laser treatment, i.e. by evaporation or spalling or any other mechanism. This is the opposite from the above teaching of Wang, et al. New dependent claims 26 and 27 are limited to embodiments in which no refractory material is removed.

Furthermore both applicants' claims 22 and 23 require that the closed vitreous layer contains the components of the refractory material, which would include SiO_2. However Wang, et al, on page 301 in conclusion 3 clearly states that their laser treatment with the laser beam that has 10 times the power densities of applicants' laser beam removes <u>all</u> the SiO_2 by evaporation from the surface of the refractory material when their sealed surface layer is formed.

This is clearly teaching the opposite from the currently worded claims 26 and 27.

The applicants' gentler CO_2 laser beam treatment is particularly advantageous because the composition of the refractory

material at the surface does not differ substantially from the composition in bulk and also the initial composition of the refractory material. Thus one skilled in the art can choose initial compositions that have an exception resistance to corrosion by the glass melt in comparison to other compositions for the refractory material and be assured that the final closed vitreous layer will have a composition that is substantially same as the initial composition.

Clearly the surface layers formed by the applicants' methods of claims 22 and 23 have an entirely different composition (vitreous, SiO_2 present) from those of Wang, et al (polycrystalline, SiO_2 completely removed). Thus the applicants' method cannot be obvious from the combined subject matter of Recasens, et al, and Wang, et al.

Furthermore the disclosures of Recasens, et al, and those of Wang, et al, should not be combined under 35 U.S.C. § 103 (a), because one skilled in the glass arts would not combine Wang with Recasens, since Wang discloses treatment for refractory materials used in metallurgy, not glass production (see the first paragraph on the first page of Wang, et al). The refractory materials of Wang, et al, are used in continuous casting methods of metallurgy where entirely different environmental conditions are found compared to

glass processing and/or production. Many properties relevant in melting processes of metals are so different from those of glass that the requirements for refractory materials used in the different fields are entirely different from each other.

For the aforesaid reasons and because of the changes in the claim wording withdrawal of the rejection of claims 22 and 23 as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301 is respectfully requested.

III. Second Obviousness Rejection

Claims (2-6)/17, 17 - 19 and 21 were rejected as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301, further in view of Torok, et al, US 3,360,353, as evidenced by Triantafyllidis, et al.

The explanation regarding the results of combining the subject matter of Wang, et al, with Recasens, et al, in the above section II are incorporated here by explicit reference thereto. The significant differences between the combined subject matter of these two prior

art references and the treatment method recited in claims 22 and 23, which is also recited in applicants' amended claim 17, described in the above section II are also incorporated here by reference thereto.

Torok, et al, is only cited to disclose a method of producing glass wherein molten glass contacts the surface of a refractory coated mandrel during processing and that the mandrel can be a Danner blowpipe in accordance with claim 17.

However Torok, et al, do not teach anything regarding laser treatments of the surface of refractory materials in order to make them more resistant to corrosion due to contact with a glass melt. Thus Torok, et al, cannot cure any of the deficiencies of Recasens, et al, and especially Wang, et al, which were pointed out in section II above and which must be cured to arrive at the treatment method according to claim 17 (which is the same as the treatment method recited in claims 22 and 23). Torok, et al, cannot suggest the modifications of the combined subject matter of these two prior art references that are necessary to arrive at applicants' claimed method according to claim 17.

Triantafyllidis, et al, was only cited on page 7 for its disclosure

of the wavelength of the CO_2 laser in order to support the rejection of claim 6/17.

Triantafyllidis, et al, does disclose laser treatment of a refractory surface but their laser treatment requires two lasers, a dye laser as well as a CO_2 laser. The dye laser provides thermal relaxation of the surface so that the thermal shock caused by the high power CO_2 laser beam does not cause further cracking, which of course is disadvantageous because cracking promotes corrosion. Applicants' claim 17 excludes use of the dye laser of Triantafyllidis, et al, because it utilizes "consisting of" wording to recite the method without the dye laser.

Thus Triantafyllidis, et al, cannot suggest the modifications of the combined subject matter of these two prior art references that are necessary to arrive at applicants' claimed method according to claim 17.

Accordingly neither Triantafyllidis, et al, nor Torok, et al, can cure the deficiencies of Wang, et al, and Recasens, et al, that are necessary to arrive at the laser treatment method of applicants' independent claim 17.

With respect to applicants' power densities (claim 3) page 7 of the Office Action observes that the power density is one of the operating parameters of the CO_2 laser and that discovery of optimum ranges for power density involves only routine skill in the art, in this case the glass arts. It is respectfully submitted that the variations of the laser power density of the prior art that would be considered routine optimization in the art would be well within the order of magnitude of the power densities used by Wang, et al, but that it is **not** routine experimentation when the power densities are varied by an order of magnitude or more.

There are a comparatively large number of possible processes, which occur when a laser beam interacts with a piece of matter, specifically a refractory material. In addition, to melting and evaporation chemical reactions can be induced by mere changes in temperature, by two photon or multiphoton processes and by photoionization -- which all depend on the level of the power densities. These processes are so varied in their nature and their occurrence thresholds are so varied that predictability is lacking when the laser power densities are changed by a factor of ten or more so that one cannot even be certain whether the same basic processes are occurring. That sort of change goes beyond the routine skill of one skilled in the glass arts.

Thus variation of the power densities of Wang, et al, to a sufficient extent to arrive at the applicants' power densities would not lead to predictable results and certainly not mere optimization of Wang, et al. For that reason in accordance with M.P.E.P. § 2143 the subject matter of the amended claim 3 would not be *prima facie* obvious from the disclosures in Recasens, et al; Wang, et al; Torok, et al; and Triantafyllidis, et al.

For the aforesaid reasons and because of the changes in the claim wording withdrawal of the rejection of claims (2-6)/17, 17 - 19 and 21 as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301, further in view of Torok, et al, US 3,360,353, as evidenced by Triantafyllidis, et al, is respectfully requested.

IV. Third Obviousness Rejection

Claims 8 and (2-6)/8 were rejected as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301, further in view of Torok, et al, US 3,360,353, and further in view of Petitbon, US 4,814,575.

Petitbon does disclose treating the surface of a ceramic (which includes but is not limited to refractory material), which for example is used in heat engines and protective plating (column 1, lines 18 to 22), with laser radiation from a single CO_2 laser and simultaneously treating the surface with a ceramic powder that is melted together with the surface (column 2, lines 41 and following; claim 1).

Petitbon teaches that the preferred ceramic materials to be treated are alumina, zirconia, silicon nitride, SiAlON, mullite and cordierite (column 4, lines 30 to 35). These materials can withstand the very high temperatures involved in heat engines and protective plating (column 1, lines 6 to 20). They have an entirely different composition from the refractory materials according to claim 8, which contain silica and MgO or chromia as well as alumina and zirconia. Because of the presence of silica the materials will change their composition if the laser power densities are sufficiently high because the silica will evaporate.

The method of Petitbon does involve treating the surface of the ceramic material with the high power beam from a continuous CO_2 laser, which has a rated power of 3 kW and a beam diameter of 4 mm, which is thus similar to the high power laser of Wang, et al,

which is distinguished from that of the applicants. The operating parameters for the preferred ceramic materials mentioned in the above paragraph are (column 4, lines 35 to 42):

Laser power density 6 to 12 kW/cm^2,

Laser energy density of 0.2 to 1 kJ/cm^2,

Scanning speed 1 to 20 cm/s, and

Alumina or zirconia powder throughput 1 to 5 grams/min.

The laser operating parameters overlap those of Wang, et al, but the laser power densities of Petitbon, like those of Wang, et al, are more than an order of magnitude greater than those of the applicants. Claim 3 of the applicants claims preferred power densities of 2 to 4 W per mm^2 in comparison to 60 to 120 W/mm^2 for Petitbon.

Petitbon, et al, specifically teaches two examples of refractory material that are sealed by their method, namely partially stabilized zirconia and yttrium-stabilized zirconia in column 4, line 42, to column 5, line 20. Significantly silica powder was never proposed for use, because under these high power densities according to Wang, et al, one would expect it to evaporate.

The *KSR* Supreme Court Opinion (*KSR Int'l Teleflex Inc.*, 82 USPQ 2^{nd} 1385, 1396 (2007)) suggests several tests for

obviousness (M.P.E.P. 2143) including an obvious-to-try test which provides a valid reason to reject a claimed invention for obviousness, **provided that** a limited number of possibilities that have predictable results are available and known to one of ordinary skill in the art. Several of the other tests, such as the test for combining known elements, also require that the outcome of the combination should be predictable (MPEP 2143).

Although obviousness does not require absolute predictability, at least some degree of predictability is required. See M.P.E.P. 2143.03 and ***In re Rinehart***, 189 U.S.P.Q. 143(C.C.P.A. 1976). The chemical arts, in contrast to the mechanical arts, are generally somewhat unpredictable despite the advances of recent years.

In the case of the instant claims it is **not** predictable that the methods of Wang, et al, and Petitbon could be successfully applied to refractory material of the claimed composition in claim 8 or indeed the refractory material as disclosed in Recasens, which comprises substantial amounts of silica and chromia or magnesia, without resulting in substantial cracking due to evaporation of volatile components, in order to produce a closed vitreous layer on the surface that comprises substantial amounts of silica. In fact the teaching of Wang, et al, together with Petitbon suggests the

opposite that the silica would be completely evaporated at the CO_2 laser operating conditions that are described in these two prior art references.

Furthermore the changes required in the laser operating conditions described in these two prior art references are more than a mere matter of routine optimization because of the large number of possible variations in the operating conditions and the large number of possible processes that may well occur at operating conditions that are so significantly different from those of the prior art.

Accordingly the present combination of prior art references teaching laser treatment methods with the disclosures of Rescasens regarding the composition of refractory materials does not establish a case of *prima facie* obviousness of applicants' amended independent method claim 8 and the claims depending on it.

For the aforesaid reasons and because of the changes in the claim wording withdrawal of the rejection of claims 8 and (2-6)/8 as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301, further in view of Torok, et al, US 3,360,353, and further in

view of Petitbon, US 4,814,575, is respectfully requested.

Should the Examiner require or consider it advisable that the specification claims and/or drawing be further amended or corrected in formal respects to put this case in condition for final allowance, then it is requested that such amendments or corrections be carried out by Examiner's Amendment and the case passed to issue. Alternatively, should the Examiner feel that a personal discussion might be helpful in advancing the case to allowance, he or she is invited to telephone the undersigned at 1-631-549 4700.

In view of the foregoing, favorable allowance is respectfully solicited.

Respectfully submitted,

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